FIPS 140-2 Non-Proprietary Security Policy
for Aruba AP-120 Series Wireless Access Points

Version 1.5

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Aruba Networks™

1322 Crossman Ave.

Sunnyvale, CA 94089-1113

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1 Introduction

This document constitutes the non-proprietary Cryptographic Module Security Policy for the AP-120 series Wireless Access Points with FIPS 140-2 Level 2 validation from Aruba Networks. This security policy describes how the AP meets the security requirements of FIPS 140-2 Level 2, and how to place and maintain the AP in a secure FIPS 140-2 mode. This policy was prepared as part of the FIPS 140-2 Level 2 validation of the product.

FIPS 140-2 (Federal Information Processing Standards Publication 140-2, *Security Requirements for Cryptographic Modules*) details the U.S. Government requirements for cryptographic modules. More information about the FIPS 140-2 standard and validation program is available on the National Institute of Standards and Technology (NIST) Web-site at:

http://csrc.nist.gov/groups/STM/cmvp/index.html

This document can be freely distributed.

1.1 Acronyms and Abbreviations

AES	Advanced Encryption Standard
AP	Access Point
CBC	Cipher Block Chaining
CLI	Command Line Interface
CO	Crypto Officer
CSEC	Communications Security Establishment Canada
CSP	Critical Security Parameter
ECO	External Crypto Officer
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
FE	Fast Ethernet
GE	Gigabit Ethernet
GHz	Gigahertz
HMAC	Hashed Message Authentication Code
Hz	Hertz
IKE	Internet Key Exchange
IPsec	Internet Protocol security
KAT	Known Answer Test
KEK	Key Encryption Key
L2TP	Layer-2 Tunneling Protocol
LAN	Local Area Network
LED	Light Emitting Diode
SHA	Secure Hash Algorithm
SNMP	Simple Network Management Protocol
SPOE	Serial & Power Over Ethernet
TEL	Tamper-Evident Label
TFTP	Trivial File Transfer Protocol
WLAN	Wireless Local Area Network

2 Product Overview

This section introduces the various Aruba Wireless Access Points, providing a brief overview and summary of the physical features of each model covered by this FIPS 140-2 security policy.

2.1 Aruba AP-120 Series Series

This section introduces the Aruba AP-120 series Wireless Access Points (APs) with FIPS 140-2 Level 2 validation. It describes the purpose of the AP, its physical attributes, and its interfaces.

Figure 1 – Aruba AP-120 Series Wireless Access Points

The Aruba AP-124 and AP are high-performance 802.11n (3x3) MIMO, dual-radio (concurrent 802.11a/n + b/g/n) indoor wireless access points capable of delivering combined wireless data rates of up to 600Mbps. These multi-function access points provide wireless LAN access, air monitoring, and wireless intrusion detection and prevention over the 2.4-2.5GHz and 5GHz RF spectrum. The access points work in conjunction with Aruba Mobility Controllers to deliver high-speed, secure user-centric network services in education, enterprise, finance, government, healthcare, and retail applications.

2.1.1 Physical Description

The Aruba AP-120 series Access Point is a multi-chip standalone cryptographic module consisting of hardware and software, all contained in a hard plastic case. The module contains IEEE 802.11a, 802.11b, 802.11g, and 802.11n transceivers, and up to 3 integrated or external omni-directional multi-band dipole antenna elements may be attached to the module.

The plastic case physically encloses the complete set of hardware and software components and represents the cryptographic boundary of the module.

The evaluated hardware versions are designated as

- AP-124-F1: Rev 01
- AP-125-F1: Rev 01

The evaluated firmware versions are designated as ArubaOS 3.3.2.18-FIPS, 3.3.2.19-FIPS, 3.3.2.20-FIPS, 3.3.2.21-FIPS, 3.4.2.3-FIPS, 3.4.4.0-FIPS and 3.4.5.1-FIPS.

2.1.1.1 Dimensions/Weight

The AP has the following physical dimensions:

- 4.9” x 5.13” x 2.0” (124mm x 130mm x 51mm)

- 15oz (0.42 Kgs)

2.1.1.2 Interfaces

The module provides the following network interfaces:

- 2 x 10/100/1000 Base-T Ethernet (RJ45) Auto-sensing link speed and MDI/MDX
- Antenna (model Aruba AP-124 only)
  - 3 x RP-SMA antenna interfaces (supports up to 3x3 MIMO with spatial diversity)
- 1 x RJ-45 console interface

The module provides the following power interfaces:

- 48V DC 802.3af or 802.3at or PoE + interoperable Power-over-Ethernet (PoE) with intelli-source PSE sourcing intelligence
- 5V DC for external AC supplied power (adapter sold separately)

2.1.1.3 Indicator LEDs

There are 5 bicolor (power, ENET 0, 1, and WLAN) LEDs which operate as follows:

Table 1- Indicator LEDs

Label	**Function**	**Action**	**Status**
PWR	AP power / ready status	Off	No power to AP
		Red	Power applied, bootloader starting
		Flashing - Green	Device booting, not ready
		On - Green	Device ready
ENET 0	Ethernet Network Link Status / Activity	Off	Ethernet link unavailable
		On - Amber	10/100Mbs Ethernet link negotiated
		On - Green	1000Mbs Ethernet link negotiated
		Flashing	Ethernet link activity
ENET 1 (Dual radio only)	Ethernet Network Link Status / Activity	Off	Ethernet link unavailable
		On - Amber	10/100Mbs Ethernet link negotiated
		On - Green	1000Mbs Ethernet link negotiated
		Flashing	Ethernet link activity
WLAN 2.4Ghz	2.4GHz Radio Status	Off	2.4GHz radio disabled
		On - Amber	2.4GHz radio enabled in WLAN mode
		On – Green	2.4GHz radio enabled in 802.11n mode
		Flashing	2.4GHz Air monitor
WLAN 5Ghz	5GHz Radio Status	Off	5GHz radio disabled
		On - Amber	5GHz radio enabled in WLAN mode

Label	Function	Action	Status
		On – Green	5GHz radio enabled in 802.11n mode
		Flashing	2.4GHz Air monitor

3 Module Objectives

This section describes the assurance levels for each of the areas described in the FIPS 140-2 Standard. In addition, it provides information on placing the module in a FIPS 140-2 approved configuration.

3.1 Security Levels

Section	Section Title	Level
1	Cryptographic Module Specification	2
2	Cryptographic Module Ports and Interfaces	2
3	Roles, Services, and Authentication	2
4	Finite State Model	2
5	Physical Security	2
6	Operational Environment	N/A
7	Cryptographic Key Management	2
8	EMI/EMC	2
9	Self-tests	2
10	Design Assurance	2
11	Mitigation of Other Attacks	N/A

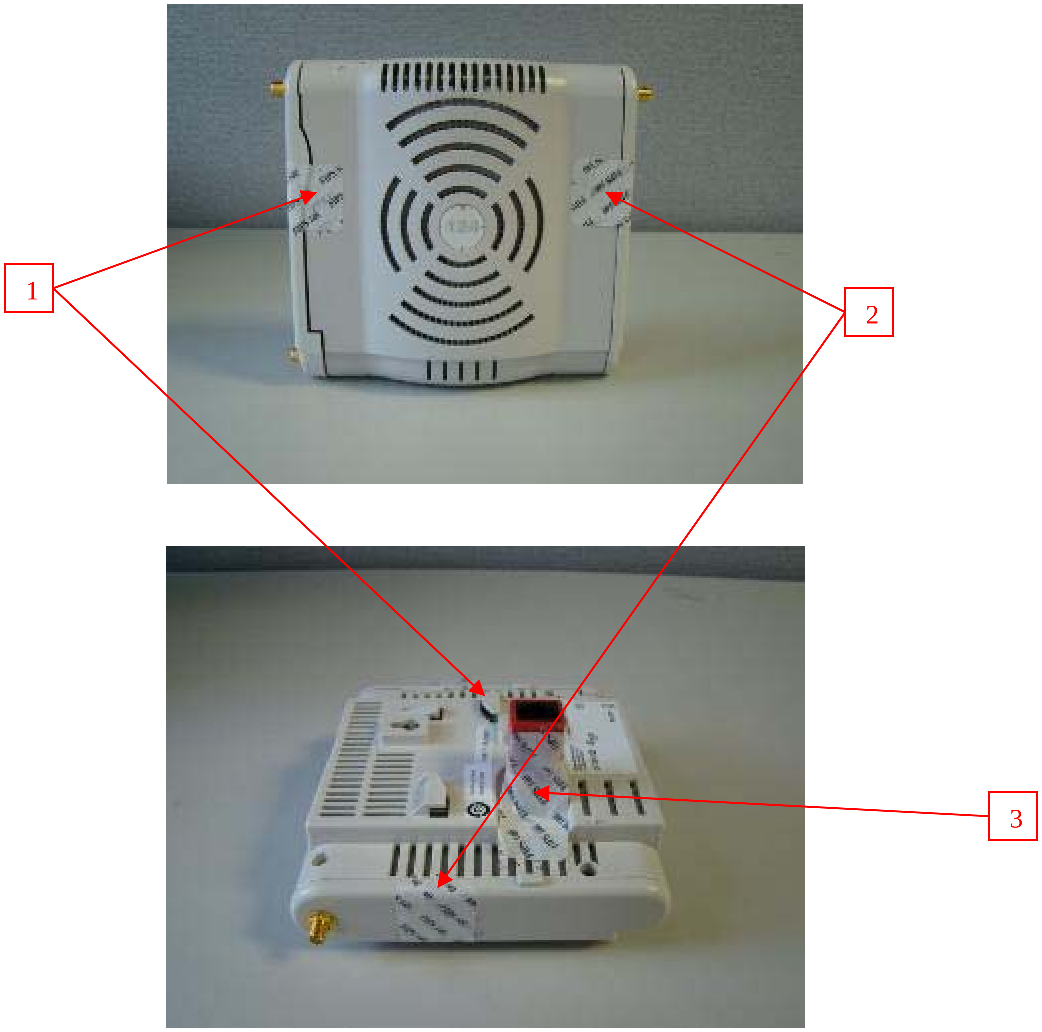
3.2 Physical Security

The Aruba Wireless AP is a scalable, multi-processor standalone network device and is enclosed in a robust plastic housing. The AP enclosure is resistant to probing (please note that this feature has not been tested as part of the FIPS 140-2 validation) and is opaque within the visible spectrum. The enclosure of the AP has been designed to satisfy FIPS 140-2 Level 2 physical security requirements.

For physical security, the AP requires Tamper-Evident Labels (TELs) to allow detection of the opening of the device, and to block the serial console port (on the bottom of the device). To protect the device from tampering, TELs should be applied by the Crypto Officer as pictured below:

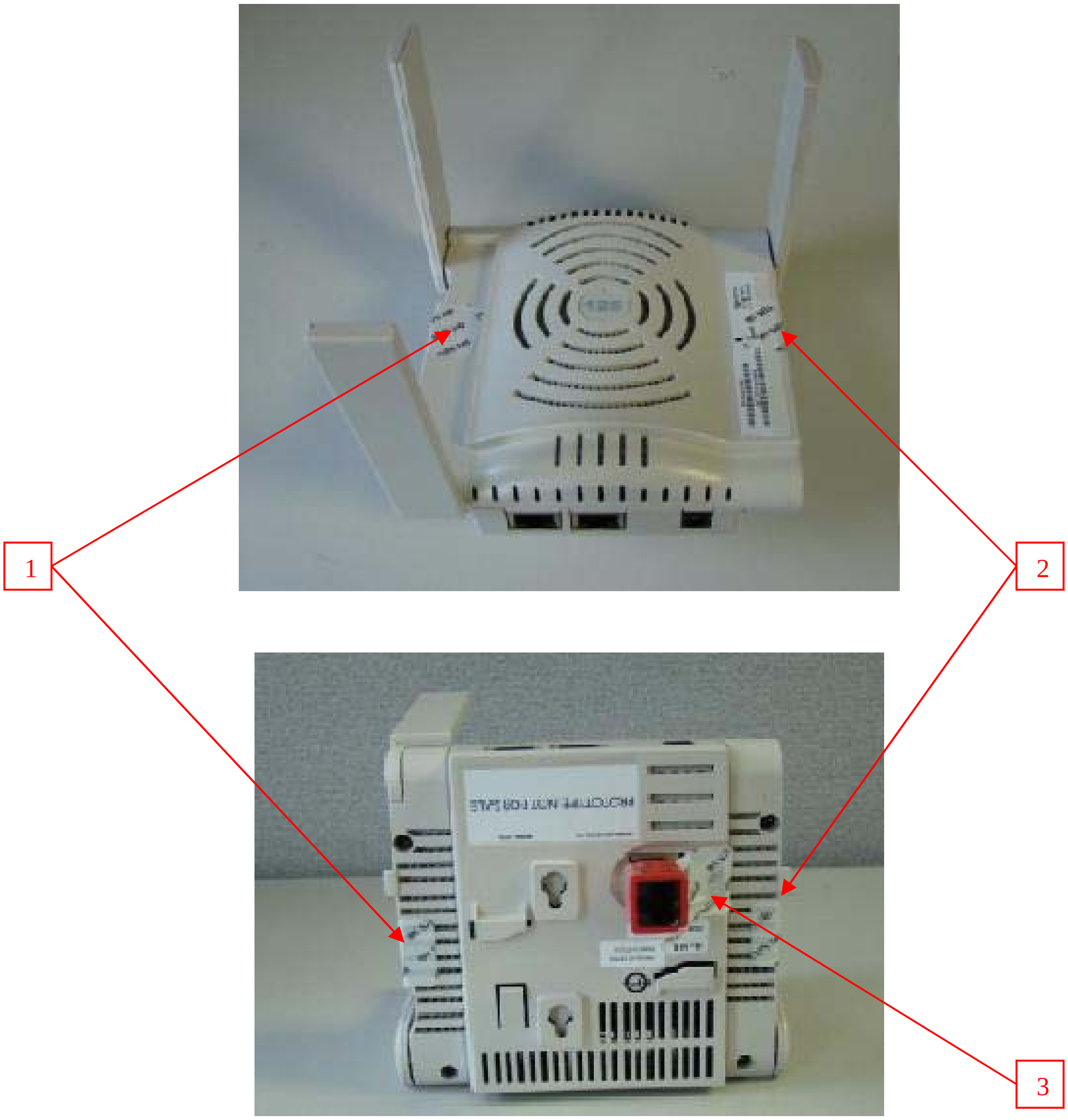
3.2.1 Aruba AP-124 TEL Placement

Following is the TEL placement for the Aruba AP-124:



3.2.2 Aruba AP-125 TEL Placement

Following is the TEL placement for the Aruba AP-125:



3.2.3 Inspection/Testing of Physical Security Mechanisms

Physical Security Mechanism	Recommended Test Frequency	Guidance
Tamper-evident labels (TELs)	Once per month	Examine for any sign of removal, replacement, tearing, etc. See images above for locations of TELs
Opaque module enclosure	Once per month	Examine module enclosure for any evidence of new openings or other access to the module internals.

3.3 Modes of Operation

The module supports multiple FIPS approved modes of operation, including the Mesh Point mode, Remote Mesh Portal mode, Remote AP mode and Control Plane Security protected AP (CPSec AP) mode, as well as a non-approved mode. This section explains how to place the module in FIPS mode, and how to verify that it is in this mode.

The access point is managed by an Aruba Mobility Controller, and access to the Mobility Controller's administrative interface via a non-networked general purpose computer is required to assist in placing the module in FIPS mode. The controller used to provision the AP is referred to below as the "staging controller". The staging controller must be provisioned with the appropriate firmware image for the module, which has been validated to FIPS 140-2, prior to initiating AP provisioning.

After setting up the Access Point by following the basic installation instructions in the module User Manual, the Crypto Officer performs the following steps:

1. Apply TELs according to the directions in section 3.2
2. Log into the administrative console of the staging controller
3. If deploying the AP in Remote AP mode or Remote Mesh Portal mode, configure the controller for supporting Remote APs/Remote Mesh Portals. A Remote Mesh Portal is a Remote AP provisioned as a Mesh Portal. For detailed instructions and steps, see Section "Configuring the Secure Remote Access Point Service" in Chapter "Remote Access Points" of the Aruba OS User Manual.
4. If deploying the AP in Remote Mesh Portal/Point mode, create the corresponding Mesh Profiles on the controller as described in detail in Section "Mesh Profiles" of Chapter "Secure Enterprise Mesh" of the Aruba OS User Manual.
    a. For mesh configurations, configure a WPA2 PSK which is 16 ASCII characters or 64 hexadecimal digits in length; generation of such keys is outside the scope of this policy
5. If deploying the AP in CPSec AP mode, configure the staging controller with CPSec under **Configuration > Controller > Control Plane Security** tab. AP will authenticate to the controller using certificate based authentication to establish IPSec. AP is configured with RSA key pair at manufacturing. AP's certificate is signed by Aruba Certification Authority (trusted by all Aruba controller's) and AP's RSA private key is protected by AP's TPM. Refer to "Configuring Control Plane Security" Section in ArubaOS User Manual for details on the steps.
6. Enable FIPS mode on the controller. This is accomplished by going to the **Configuration > Network > Controller > System Settings** page (this is the default page when you click the **Configuration** tab), and clicking the **FIPS Mode for Mobility Controller Enable** checkbox.
7. Enable FIPS mode on the AP. This accomplished by going to the **Configuration > Wireless > AP Configuration > AP Group** page. There, you click the **Edit** button for the appropriate AP group, and then select **AP > AP System Profile.** Then, check the "Fips Enable" box, check "Apply", and save the configuration.
8. If the staging controller does not provide PoE, either ensure the presence of a PoE injector for the LAN connection between the module and the controller, or ensure the presence of a DC power supply appropriate to the particular model of the module
9. Connect the module via an Ethernet cable to the staging controller; note that this should be a direct connection, with no intervening network or devices; if PoE is being supplied by an injector, this represents the only exception. That is, nothing other than a PoE injector should be present between the module and the staging controller.
10. Once the module is connected to the controller by the Ethernet cable, navigate to the **Configuration > Wireless > AP Installation page,** where you should see an entry for the AP. Select that AP, click the "Provision" button, which will open the provisioning window. Now provision

the AP as Remote AP/Mesh Point/Remote Mesh Portal/CPSec AP by filling in the form appropriately. Detailed steps are listed in Section “Provisioning an Individual AP” of Chapter “The Basic User-Centric Networks” of the Aruba OS User Guide. Click “Apply and Reboot” to complete the provisioning process.

a. During the provisioning process as Remote AP or Remote Mesh Portal, if Pre-shared key is selected to be the Remote IP Authentication Method, the IKE pre-shared key (which is at least 8 characters in length) is input to the module during provisioning. Generation of this key is outside the scope of this policy. In the initial provisioning of an AP, this key will be entered in plaintext; subsequently, during provisioning, it will be entered encrypted over the secure IPSec session. If certificate based authentication is chosen, AP’s RSA key pair is used to authenticate AP to controller during IPSec. AP’s RSA private key is contained in AP’s TPM and is generated at manufacturing time in factory.

b. During the provisioning process as Mesh Point or Remote Mesh Portal, the WPA2 PSK is input to the module via the corresponding Mesh cluster profile. This key is stored on flash encrypted.

c. For CPSec AP mode, the AP always uses certificate based authentication to establish IPSec connection with controller. AP uses the RSA key pair assigned to it at manufacturing to authenticate itself to controller during IPSec. Refer to “Configuring Control Plane Security” Section in Aruba OS User Manual for details on the steps to provision an AP with CPSec enabled on controller.

11. Via the logging facility of the staging controller, ensure that the module (the AP) is successfully provisioned with firmware and configuration
12. Terminate the administrative session
13. Disconnect the module from the staging controller, and install it on the deployment network; when power is applied, the module will attempt to discover and connect to an Aruba Mobility Controller on the network using IPsec.

To verify that the module is in FIPS mode, do the following:

1. Log into the administrative console of the Aruba Mobility Controller
2. Verify that the module is connected to the Mobility Controller
3. Verify that the module has FIPS mode enabled by issuing command “show ap ap-name <ap-name> config”
4. Terminate the administrative session

3.4 Operational Environment

The operational environment is non-modifiable. The Operating System (OS) is Linuz, a real-time multi-threaded operating system that supports memory protection between processes. Access to the underlying Linux implementation is not provided directly. Only Aruba-provided Crypto Officer interfaces are used. There is no user interface provided.

3.5 Logical Interfaces

The physical interfaces are divided into logical interfaces defined by FIPS 140-2 as described in the following table.

Table 2 - FIPS 140-2 Logical Interfaces

FIPS 140-2 Logical Interface	**Module Physical Interface**
Data Input Interface	10/100/1000 Ethernet Ports 802.11a/b/g/n Radio Transceiver
Data Output Interface	10/100/1000 Ethernet Ports 802.11a/b/g/n Radio Transceiver
Control Input Interface	10/100/1000 Ethernet Ports (PoE) 5V power input jack
Status Output Interface	10/100/1000 Ethernet Ports 802.11a/b/g/n Radio Transceiver RJ-45 Serial Console Interface LEDs
Power Interface	Power Supply PoE

Data input and output, control input, status output, and power interfaces are defined as follows:

- Data input and output are the packets that use the networking functionality of the module.
- Control input consists of manual control inputs for power and reset through the power interfaces (5V DC or PoE). It also consists of all of the data that is entered into the access point while using the management interfaces.
- Status output consists of the status indicators displayed through the LEDs, the status data that is output from the module while using the management interfaces, and the log file.
    - LEDs indicate the physical state of the module, such as power-up (or rebooting), utilization level, and activation state. The log file records the results of self-tests, configuration errors, and monitoring data.
- A power supply may be used to connect the electric power cable. Operating power may also be provided via Power Over Ethernet (POE) device when connected. The power is provided through the connected Ethernet cable.

The module distinguishes between different forms of data, control , and status traffic over the network ports by analyzing the packet headers and contents.

4 Roles, Authentication, and Services

4.1 Roles

The module supports the roles of Crypto Officer, User, and Wireless Client; no additional roles (e.g., Maintenance) are supported. Administrative operations carried out by the Aruba Mobility Controller map to the Crypto Officer role. The Crypto Officer has the ability to configure, manage, and monitor the module, including the configuration, loading, and zeroization of CSPs.

Defining characteristics of the roles depend on whether the module is configured as a Remote AP, CPSec AP or as a Mesh AP:

- Remote AP:
  - Crypto Officer role: the Crypto Officer is the Aruba Mobility Controller that has the ability to configure, manage, and monitor the module, including the configuration, loading, and zeroization of CSPs.
  - User role: in the standard configuration, the User operator shares the same services and authentication techniques as the Mobility Controller in the Crypto Officer role.
  - Wireless Client role: in Remote AP configuration, a wireless client can create a connection to the module using WPA2 and access wireless network access/bridging services. In advanced Remote AP configuration, when Remote AP cannot communicate with the controller, the wireless client role authenticates to the module via WPA2-PSK only.
- CPSec AP:
  - Crypto Officer role: the Crypto Officer is the Aruba Mobility Controller that has the ability to configure, manage, and monitor the module, including the configuration, loading, and zeroization of CSPs.
  - User role: in the standard configuration, the User operator shares the same services and authentication techniques as the Mobility Controller in the Crypto Officer
  - Wireless Client role: in CPSec AP configuration, a wireless client can create a connection to the module using WPA2 and access wireless network access services.
- Mesh AP (Mesh Point or Remote Mesh Portal configuration):
  - Crypto Officer role: the Crypto Officer role is the Aruba Mobility Controller that has the ability to configure, manage, and monitor the module, including the configuration, loading, and zeroization of CSPs.
  - User role: the second (or third, or nth) AP in a given mesh cluster
  - Wireless Client role: in Mesh AP configuration, a wireless client can create a connection to the module using WPA2 and access wireless network access services.

4.1.1 Crypto Officer Authentication

The Aruba Mobility Controller implements the Crypto Officer role. Connections between the module and the mobility controller are protected using IPsec. Crypto Officer authentication is accomplished via either proof of possession of the IKE preshared key or AP's RSA key pair, which occurs during the IKE key exchange. In CPSec AP mode, AP can only authenticate using RSA key (stored in TPM).

4.1.2 User Authentication

Authentication for the User role depends on the module configuration. When the module is configured as a Mesh AP, the User role is authenticated via the WPA2 preshared key. When the module is configured as a Remote AP, the User role is authenticated via the same IKE pre-shared key/RSA key pair that is used by the Crypto Officer. In CPSec AP mode, User authentication is accomplished via same RSA key pair that is used by the Crypto Officer.

4.1.3 Wireless Client Authentication

The wireless client role, in the Remote AP, Mesh AP or CPSec AP configuration authenticates to the module via WPA2 .. WEP and/or Open System configurations are not permitted in FIPS mode. In advanced Remote AP configuration, when Remote AP cannot communicate with the controller, the wireless client role authenticates to the module via WPA2-PSK only.

4.1.4 Strength of Authentication Mechanisms

The following table describes the relative strength of each supported authentication mechanism.

Authentication Mechanism	**Mechanism Strength**
IKE shared secret (CO role)	For IKE, there are a 95^8 (=6.63 x 10^15) possible preshared keys. In order to test the guessed key, the attacker must complete an IKE aggressive mode exchange with the module. IKE aggressive mode consists of a 3 packet exchange, but for simplicity, let's ignore the final packet sent from the AP to the attacker. An IKE aggressive mode initiator packet with a single transform, using Diffie-Hellman group 2, and having an eight character group name has an IKE packet size of 256 bytes. Adding the eight byte UDP header and 20 byte IP header gives a total size of 284 bytes (2272 bits). The response packet is very similar in size, except that it also contains the HASH_R payload (an additional 16 bytes), so the total size of the second packet is 300 bytes (2400 bits). Assuming a link speed of 1Gbits/sec (this is the maximum rate supported by the module), this gives a maximum idealized guessing rate of 60,000,000,000 / 4,672 = 12,842,466 guesses per minute. This means the odds of guessing a correct key in one minute is less than 12,842,466/(6.63x10^15) = 1.94 x 10^-9, which is much less than 1 in 10^5.

Authentication Mechanism	Mechanism Strength
Wireless Client WPA2-PSK (Wireless Client Role)	For WPA2-PSK there are at least 95^16 (=4.4 x 10^31) possible combinations. In order to test a guessed key, the attacker must complete the 4-way handshake with the AP. Prior to completing the 4-way handshake, the attacker must complete the 802.11 association process. That process involves the following packet exchange: • Attacker sends Authentication request (at least 34 bytes) • AP sends Authentication response (at least 34 bytes) • Attacker sends Associate Request (at least 36 bytes) • AP sends Associate Response (at least 36 bytes) Total bytes sent: at least 140. Note that since we do not include the actual 4-way handshake, this is less than half the bytes that would actually be sent, so the numbers we derive will absolutely bound the answer. The theoretical bandwidth limit for IEEE 802.11n is 300Mbit, which is 37,500,000 bytes/sec. In the real world, actual throughput is significantly less than this, but we will use this idealized number to ensure that our estimate is very conservative. This means that the maximum number of associations (assume no delays, no inter-frame gaps) that could be completed is less than 37,500,000/214 = 267,857 per second, or 16,071,429 associations per minute. This means that an attacker could certainly not try more than this many keys per second (it would actually be MUCH less, due to the added overhead of the 4-way handshake in each case), and the probability of a successful attack in any 60 second interval MUST be less than 16,071,429/(4.4 x 10^31), or roughly 1 in 10^25, which is much less than 1 in 10^5.
Mesh AP WPA2 PSK (User role)	Same as Wireless Client WPA2-PSK above
Certificate based authentication –RSA key pair (CO role)	The module supports RSA 2048-bit keys, which has at least 112-bits of equivalent strength. The probability of a successful random attempt is 1/(2^112), which is less than 1/1,000,000. The probability of a success with multiple consecutive attempts in a one-minute period is 5.6e7/(2^112), which is less than 1/100,000.

4.2 Services

The module provides various services depending on role. These are described below.

4.2.1 Crypto Officer Services

Service	Description	**CSPs Accessed** (see section 6 below for complete description of CSPs)
FIPS mode enable/disable	The CO selects/de-selects FIPS mode as a configuration option.	None.
Key Management	The CO can configure/modify the IKE shared secret (The RSA private key is protected by the TPM and cannot be modified) and the WPA2 PSK (used in advanced Remote AP configuration). Also, the CO/User implicitly uses the KEK to read/write configuration to non-volatile memory.	• IKE shared secret • WPA2 PSK • KEK
Remotely reboot module	The CO can remotely trigger a reboot	KEK is accessed when configuration is read during reboot. The firmware verification key and firmware verification CA key are accessed to validate firmware prior to boot.
Self-test triggered by CO/User reboot	The CO can trigger a programmatic reset leading to self-test and initialization	KEK is accessed when configuration is read during reboot. The firmware verification key and firmware verification CA key are accessed to validate firmware prior to boot.
Update module firmware	The CO can trigger a module firmware update	The firmware verification key and firmware verification CA key are accessed to validate firmware prior to writing to flash.
Configure non-security related module parameters	CO can configure various operational parameters that do not relate to security	None.

Service	Description	CSPs Accessed (see section 6 below for complete description of CSPs)
Creation/use of secure management session between module and CO	The module supports use of IPsec for securing the management channel.	• IKE Preshared Secret • DH Private Key • DH Public Key • IPsec session encryption keys • IPsec session authentication keys • RSA key pair
Creation/use of secure mesh channel	The module requires secure connections between mesh points using 802.11i	• WPA2-PSK • 802.11i PMK • 802.11i PTK • 802.11i EAPOL MIC Key • 802.11i EAPOL Encryption Key • 802.11i AES-CCM key • 802.11i GMK • 802.11i GTK • 802.11i AES-CCM key
System Status	CO may view system status information through the secured management channel	See creation/use of secure management session above.

Note: CO role module services are same across all AP modes.

4.2.2 User Services

The following Module Services are provided for the User role in Mesh AP mode:

Service	Description	CSPs Accessed (see section 6 below for complete description of CSPs)
Generation and use of 802.11i cryptographic keys	When the module is in mesh configuration, the inter-module mesh links are secured with 802.11i.	• 802.11i PMK • 802.11i PTK • 802.11i EAPOL MIC Key • 802.11i EAPOL Encryption Key • 802.11i AES-CCM key

Service	Description	**CSPs Accessed** (see section 6 below for complete description of CSPs)
		• 802.11i GMK • 802.11i GTK
Use of WPA preshared key for establishment of IEEE 802.11i keys	When the module is in mesh configuration, the inter-module mesh links are secured with 802.11i. This is authenticated with a shared secret	• WPA2 PSK

For Remote AP and CPSec AP mode User services, please refer to Section 4.2.1, “Crypto Officer Services”

4.2.3 Wireless Client Services

The following Module Services are provided for the Wireless Client role:

Service	Description	**CSPs Accessed** (see section 6 below for complete description of CSPs)
Generation and use of 802.11i cryptographic keys	In all modes, the links between the module and wireless client are secured with 802.11i.	• 802.11i PMK • 802.11i PTK • 802.11i EAPOL MIC Key • 802.11i EAPOL Encryption Key • 802.11i AES-CCM key • 802.11i GMK • 802.11i GTK
Use of WPA preshared key for establishment of IEEE 802.11i keys	When the module is in advanced Remote AP configuration, the links between the module and the wireless client are secured with 802.11i. This is authenticated with a shared secret only.	• WPA2 PSK
Wireless bridging services	The module bridges traffic between the wireless client and the wired network.	None

4.2.4 Unauthenticated Services

The module provides the following unauthenticated services, which are available regardless of role. No CSPs are accessed by these services.

- System status – SYSLOG and module LEDs
- 802.11 a/b/g/n
- FTP
- TFTP
- NTP
- GRE tunneling of 802.11 wireless user frames (when acting as a “Local AP”)
- Reboot module by removing/replacing power
- Self-test and initialization at power-on

5 Cryptographic Key Management

5.1 Implemented Algorithms

FIPS-approved cryptographic algorithms have been implemented in hardware and software. Some modules provide Cavium Octeon 5010 hardware encryption acceleration for bulk cryptographic operations for the following FIPS-approved algorithms:

- AES (Cert. #861) - CBC; 128,192,256 bits - CCM; 128 bits, Assoc. Data Len Range: 15 - 30, Payload Length Range: 0 - 32, Nonce Length(s): 13, Tag Length(s): 8
- TDES (Cert. #708) - CBC; 192 bits (168 used)/1,2,3 keys keying option
- SHA-1 (Cert. #856) - BYTE oriented
- HMAC SHA-1 (Cert. #478)

Hardware encryption is provided for the following non-FIPS-approved algorithms.

- MD5

The firmware implementation uses OpenSSL FIPS crypto library version 1.1.1, as well as the UBOOT boot loader. The firmware implements the following FIPS-approved algorithms:

- OpenSSL Module
  - AES (Cert. #900) - CBC: 128, 192, 256 bits
  - Triple-DES (Cert. #734)- CBC key options Keying Options 1,2,3 used
  - SHA-1 (Cert. #892) - BYTE oriented
  - HMAC SHA-1 (Cert. #503)
  - RSA (Cert. #436)
  - RNG (Cert. #516)

- UBOOT Bootloader cryptographic module
  - SHA-1 (Cert. #891) - BYTE oriented
  - RSA (Cert. #435)

The firmware implements the following non-FIPS-approved algorithms in firmware:

- MD5

The firmware implements the following non-approved but allowed algorithms in firmware:

- Diffie-Hellman

Diffie-Hellman key establishment methodology provides 80-bits of encryption strength.

6 Critical Security Parameters

The following Critical Security Parameters (CSPs) are used by the module:

CSP	CSP TYPE	GENERATION	STORAGE And ZEROIZATION	USE
KEK	TDES key	Hard-coded	Stored in flash, zeroized by the 'ap wipe out flash' command.	Encrypts IKE preshared keys and configuration parameters
IKE Pre-shared secret	64 character preshared key	Externally generated	Encrypted in flash using the KEK; zeroized by updating through administrative interface, or by the 'ap wipe out flash' command.	Module and crypto officer authentication during IKE; entered into the module in plaintext during initialization and encrypted over the IPSec session subsequently.
IPsec session encryption keys	168-bit TDES, 128/192/256 bit AES keys;	Established during Diffie-Hellman key agreement	Stored in plaintext in volatile memory; zeroized when session is closed or system powers off	Secure IPsec traffic
IPsec session authentication keys	HMAC SHA-1 keys	Established during Diffie-Hellman key agreement	Stored in plaintext in volatile memory; zeroized when session is closed or system powers off	Secure IPsec traffic
IKE Diffie-Hellman Private key	1024-bit Diffie-Hellman private key	Generated internally during IKE negotiation	Stored in plaintext in volatile memory; zeroized when session is closed or system is powered off	Used in establishing the session key for IPsec
IKE Diffie-Hellman public key	1024-bit Diffie-Hellman private key	Generated internally during IKE negotiation	Stored in plaintext in volatile memory	Used in establishing the session key for IPsec
PRNG seeds	PRNG Seed (8 bytes)	Generated by non-approved PRNG	In volatile memory only; zeroized on reboot	Seed PRNG
PRNG Keys	PRNG Keys (16 bytes, TDES 2-keying option)	Generated by non-approved PRNG	In volatile memory only; zeroized on reboot	PRNG operation

CSP	CSP TYPE	GENERATION	STORAGE And ZEROIZATION	USE
WPA2 PSK	16-64 character shared secret used to authenticate mesh connections and in remote AP advanced configuration	Externally generated	Encrypted in flash using the KEK; zeroized by updating through administrative interface, or by the 'ap wipe out flash' command.	Used to derive the PMK for 802.11i mesh connections between APs and in advanced Remote AP connections; programmed into AP by the controller over the IPSec session.
802.11i Pairwise Master Key (PMK)	512-bit shared secret used to derive 802.11i session keys	Internally generated using WPA PSK	In volatile memory only; zeroized on reboot	Used to derive 802.11i Pairwise Transient Key (PTK)
802.11i Pairwise Transient Key (PTK)	512-bit shared secret from which Temporal Keys (TKs) are derived	Derived during 802.11i 4-way handshake	In volatile memory only; zeroized on reboot	All session encryption/decryption keys are derived from the PTK
802.11i EAPOL MIC Key	128-bit shared secret used to protect 4-way (key) handshake	Derived from PTK	In volatile memory only; zeroized on reboot	Used for integrity validation in 4-way handshake
802.11i EAPOL Encr Key	128-bit shared secret used to protect 4-way handshakes	Derived from PTK	In volatile memory only; zeroized on reboot	Used for confidentiality in 4-way handshake
802.11i data AES-CCM encryption/mic key	128-bit AES-CCM key	Derived from PTK	Stored in plaintext in volatile memory; zeroized on reboot	Used for 802.11i packet encryption and integrity verification (this is the CCMP or AES-CCM key)
802.11i Group Master Key (GMK)	256-bit secret used to derive GTK	Internally generated from approved RNG	Stored in plaintext in volatile memory; zeroized on reboot	Used to derive Group Transient Key (GTK)
802.11i Group Transient Key (GTK)	256-bit shared secret used to derive group (multicast) encryption and integrity keys	Internally derived by AP which assumes "authenticator" role in handshake	Stored in plaintext in volatile memory; zeroized on reboot	Used to derive multicast cryptographic keys

CSP	**CSP TYPE**	**GENERATION**	**STORAGE And ZEROIZATION**	**USE**
802.11i Group AES-CCM Data Encryption/MIC Key	128-bit AES-CCM key derived from GTK	Derived from 802.11 group key handshake	Stored in plaintext in volatile memory; zeroized on reboot	Used to protect multicast message confidentiality and integrity (AES-CCM)
Firmware verification key	2048-bit RSA public key	Externally generated	Stored in plaintext in bootloader image	Used to validate the signature on firmware image
Firmware CA key	2048-bit RSA public key	Externally generated	Stored in plaintext in bootloader image	Used to validate certificate containing Firmware verification key
RSA private Key	2048-bit RSA private key	Generated on the AP (remains in AP at all times)	Stored in and protected by AP's TPM	Used for IKE authentication when AP is authenticating using certificate based authentication
RSA public Key	2048-bit RSA public key	Generated on the AP	Stored in plaintext in flash.	Used for IKE authentication when AP is authenticating using certificate based authentication

7 Self Tests

The module performs both power-up and conditional self-tests. In the event any self-test fails, the module enters an error state, logs the error, and reboots automatically.

The module performs the following power-up self-tests:

- Software Integrity Test–The module checks the integrity of its firmware by validating a 2048-bit RSA digital signature over the same image to ensure its authenticity.
- Cryptographic Algorithm Tests – These tests are run at power-up for the TDES encryption/decryption, AES and AES-CCM encryption/decryption, SHA-1 known answer test, HMAC SHA-1 known answer test, RSA signature verification, and the PRNG random data generation.

The following Conditional Self-tests are performed in the module:

- Continuous Random Number Generator Test–This test is run upon generation of random data by the module's random number generators to detect failure to a constant value.

These self-tests are run for the Cavium hardware cryptographic implementation as well as for the OpenSSL implementation.

Self-test results are written to the serial console.

In the event of a KATs failure, the AP logs different messages, depending on the error.

For an OpenSSL KAT failure:

```
AP rebooted [DATE][TIME] : Restarting System, SW FIPS KAT failed
```

For an AES cavium hardware POST failure:

```
Starting HW SHA1 KAT ...Completed HW SHA1 KAT
Starting HW HMAC-SHA1 KAT ...Completed HW HMAC-SHA1 KAT
Starting HW DES KAT ...Completed HW DES KAT
Starting HW AES KAT ...Restarting system.
```